A LINEAR MEASUREMENT SYSTEM FOR LARGE ARRAY ANTENNAS

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ABSTRACT

A system for measuring large linear arrays of antennas has been developed, fabricated and tested. The system consists on a 12 meters structure where the antenna under test (a L band array of dipoles in this case) is positioned. The measurement probe (another dipole) moves on a linear slide and stops in front of each element of the array to acquire the electric field. All the system is installed on an semi-anechoic chamber, that can be lifted (with two synchronized stepped motors). This semi-anechoic chamber covers the top and side parts of the structure. The bottom part consists on a metallic reflector, that controls the reflections from each antenna element. Once the data is acquired, the data are processed to obtain the far field patterns and parameters of the antenna array (element amplitude and phase, beam width, side level, beam pointing …) All the results are presented in a windows environment, and all the system is integrated in a friendly user interface.

Keywords: Linear system, antenna measurement, array, radar.

1. Introduction

Large antennas need special measurement system. This paper presents the measurement system developed for the measurement of the radiation parameters of linear arrays in L-band. These antennas are for RADAR applications, with possibility of operating with a sum or a difference pattern. The maximum length of the array antennas (up to 11 meters) requires a specially long linear system. The fabricated system is a 12 meters structure. The antenna radiates the field, and it is fixed on the structure. The probe moves along the linear slide, stopping in front of each array element, acquiring the radiated near field (in amplitude and phase). This acquired field is processed, based on FFT techniques, to obtain the radiation pattern in the far field for the plane of the array. A post processing is realized to obtain the radiation pattern main parameters.

This paper is divided in following sections: section 2 describes the main characteristics and specifications of the system, section 3 describes the mechanical part of the system, including the anechoic structure. Section 4 describes the control system. Section 5 describes the radio frequency subsystem and, finally, section 6 describes the data processing and result representation.

2. Specifications and main characteristics of the system

The measurement range is divided into the following subsystems:

- Linear slide and antenna array supporting structure.
- Anechoic and reflector systems, including an elevator for antenna array installation.
- Positioner controlling system.
- Radio frequency subsystem.
- Acquisition, processing and representation software.

The complete system is installed in a room. A picture of the system is presented in Figure 1.

Figure 1. Picture of the antenna measurement system

The main specifications of the system are:

- Useful margin of the linear slide >12.6 metros
- Rectitude in Y and Z axis: assured value: ±1 mm. Objective value ±0.5 mm
- Positioning precision in X axis: ±0.8 mm
- Probe Velocity: 8 cm/sec
- Maximum measurement time: 4 minutes
- Minimum frequency of the anechoic system: 1 GHz
- Frequency range of the antenna system: 1.2 to 1.4 GHz

3. Mechanical system

The mechanical system includes the following elements:

- Linear slide and array supporting structure.
- Reflector
- Semi anechoic box
- Elevator system

3.1 Linear slide and array supporting structure

The linear slide is installed over 4 3280 mm long modules, made on aluminum commercial profiles. Each one is rigidized with transversal profiles. The distance between drills is 180 mm, in order to set the precision linear guides. These linear guides have lengths equal to 300 mm and incorporate the rack. Each module is installed over 8 legs to be able to align transversally and longitudinally, on the complete 13.2 meters. The alignment was realized with a quadrant detector and a laser.

The table of the linear slide moves on rollers, assuring a good repeatability in the Y and Z axes (better than ±100µm). The engine is hidden from the direct line of sight of the probe. The table movement is realized on a commercial stepped engine, with an encoder to assure a correct positioning of the table, together with the desired repeatability. The positioning precision is fixed by the step (<0.01 mm) and by the residual errors of the rack (<0.3 mm). The system can be calibrated measuring the position at the first and final point.

3.2 Reflector

The antenna array is placed on a reflector to avoid the radiation on the floor. This reflector is divided in two halves, one is fixed to the array supporting structure, and the other can be moved in order to allow the array antenna installation. This module has wheels to facilitate the operation. The reflectors have the possibility of changing the length of the wheels in order to compensate the possible planarity errors of the room floor.

Figure 2.- Linear slide

Figure 3.- Half reflector

3.3 Semi anechoic box

The system is covered with a semi anechoic box whose dimensions are 14740 mm x 2245 mm x 1340 mm (2050 mm including the legs). This box is open in his lower side. This material is fixed on 15 mm sandwich laminates. This structure is very light to reduce the weight of the system.

The box was fabricated in 8 modules to facilitate the transportation and installation. Also, the box was built using commercial aluminum profiles.

The anechoic structure allows a good performance at 1 GHz. The absorbing material is 18 inches pyramidal (RANTEC EHP-18PCL), that assures a reflectivity better than 40 dB with normal incidence at 1 GHz.

The box has 4 legs in its extremes, to free 710 mm between the lower part of the anechoic system and the floor, as security measurement. Also, this separation allows to the operation personnel the access to the input connectors of the antenna array without moving the elevator.

Figure 4.- Partial view of the anechoic box

Figure 5.- One of the two elevators

3.4 Elevator system

The anechoic system can be elevated with two elevators placed at each side of the range. This operation is required for the installation of the array under test. Each elevator is placed on a tower, built with commercial aluminum profiles. Each tower is fixed to the room floor. On each tower two pulleys are installed to support the belts. The counterweights are 1600 kg steel blocks.

The two pulleys of each elevator use the same axis, that are coupled to the stepped motors. Both motors are synchronous, to get a smooth movement. The motors are controlled through PLC systems, identical to the one used for the linear slide.

Although the system is oversized, there are several security systems: first, the motors include electromagnetic brakes to avoid the system reversibility. Besides, there is a emergency push button to stop the movement close to the operator, together another button in the control software. Also, the electrical system is ready to stop the movements in case of lack of electrical current. Finally, four mechanical elements are placed in the tower legs to avoid the fall of the box in case of rupture of the pulleys., when the operators are installing the antenna array.

4. Control system

The control system is based on the PHYTRON model GSP 93-70 MINI 24V. This system is controlled through a serial bus (RS232 or RS485), and it is prepared to feed stepped motors, and read the position from an optical encoder system. The inner electronic allows 0.225º resolution.

It has been developed a software that controls all the system, including the linear slide movement, elevator system and RF. All these equipments are controlled through serial bus or LAN.

5. Radio frequency system

The radio frequency system composed of:

- Vector network analyzer Agilent ENA E5070B (300 kHz to 3 GHz).
- Agilent electronic calibration system ECAL85029C
- Antenna probe: short dipole excited through a bal-un, working on 1.2 GHz to 1.4 GHz.
- Semi-rigid cables and 10 meters flexible cable for the slide (GORE-PHASEFLEX)
- Electromechanical coaxial switch to excite a reference element, controlled by the computer.

The radiation from this element is taken for compensating the measurements in case of thermal deviations.

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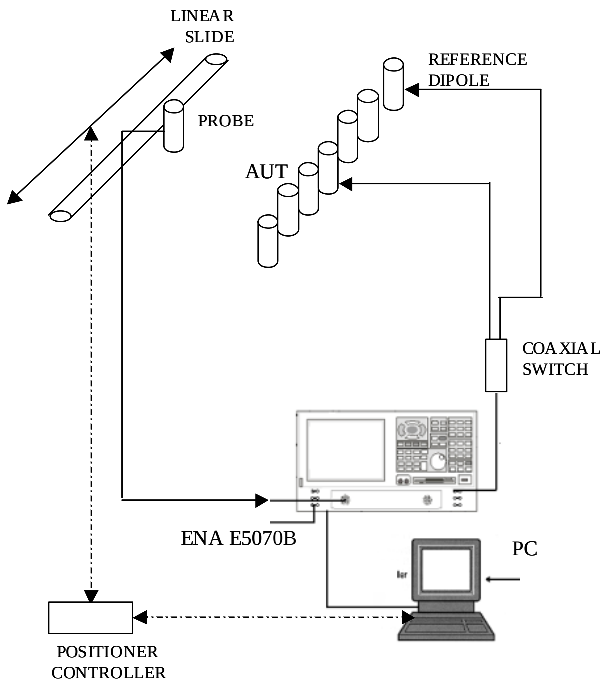

Figure 6.- RF system

6. Acquisition, processing and representation software

The software allows the acquisition, the probe positioning, the data processing and the results presentation. Also, it compares the results with specifications and marks if the antenna arrays pass or fail. The acquisition is multi frequency, so several frequencies can be measured in a scan.

The software is programmed in Agilent VEE© environment, but it uses Matlab© scripts for the mathematical algorithms. It is on a friendly user environment, and it incorporates a help.

The program is divided in two blocks: data acquisition and data processing:

Data acquisition module: it includes the routines to control the positions and radio frequency components. All the results (reflection coefficient and amplitude and phase near field data) are saved on ascii files.

Data processing and results representation: this module calculates the antenna parameters, and compares them with the specified values, giving a pass or fail message. Also, it incorporates the possibility of obtaining a report including all the measurements using Microsoft Word©. This module can process several array antennas, to simulate a planar array. The far field results are also given in ascii files.

Some of the results that the program is able to provide at each measured frequency are:

- Maximum VSWR, including the frequency.
- Average insertion phase of the measurement.
- Length of a line stretcher to achieve a determined insertion phase.
- 3, 26 and 30 dB beam width.
- Side lobe levels.
- Bore sighting.

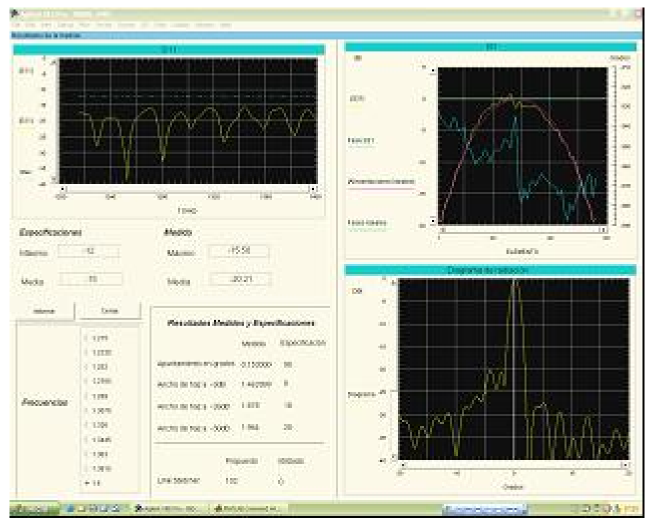

Figure 7.- Capture of one of the software windows

7. Conclusions

A linear system has been installed for measuring large antenna arrays. This system operates in L band and it is actually working. All the system has been designed by a University group, with capabilities in antenna measurement: including radio frequency, mechanical components, software development … The system has been designed, built and tested in less than 8 months. Nowadays Indra engineers are using it for testing and designing their array antennas.

8. ACKNOWLEDGMENTS

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